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SPECTROSCOPIC NOTES ON OBSERVATIONS—CHIEFLY SOLAR—1879-80.

By Prof. C. A. Young, of Princeton, N. J.

(*a*) The magnesium lines of the *b* group and the sodium lines have been seen several times (first on June 5, 1880) *doubly*-reversed in the chromosphere spectrum—*i. e.* a bright line appeared as usual in the centre of the broad dark shade, and then this bright line widened and a thin dark line appeared in its centre. The phenomenon seems to be the exact correlative of the double-reversal of the bright sodium lines observable in the flame of a Bunsen burner under certain circumstances.

(*b*) I have recently been able to repeat the observations on the H lines first made at Sherman in 1872. In the spectrum of the chromosphere I find both H_1, and H_2, (or K, as some call H_2) to be *always* reversed; and what is more, H_1 is *double*, the principal line, which is in the centre of the dark shade, being accompanied by another of about half the strength, one division of Angstrom's scale lower—*i. e.* less refrangible. Since last March I have always been able to observe the two H's whenever I could see h, and H_1 *invariably* double.

In the neighborhood of sun spots however, though both H and K are usually reversed on the solar disc, H_1 is *not* double; its attendant line therefore belongs strictly to the spectrum of the chromosphere, and seems to be identical with No. 271 of my catalogue of chromosphere lines, though its wave length is about 3969 instead of 3970.

The observations were made with grating of 17,280 lines to inch; collimator and telescope 12-inch focus.

(*c*) A high dispersion spectoscope has been constructed by combining the above-mentioned grating, having nearly four square inches of ruled surface, with collimator and telescope of 3 inches aperture and 42 inches focus, the magnifying power employed varying from 50 to 200. The apparatus is strapped to the tube of the equatorial, and thus kept directed to the sun, an image of which is formed on the slit by an anachromatic lens of 3 inches aperture.

The performance of the grating is admirable when perfectly flat—a force of ¼ oz. applied at one corner is however sufficient to distort the plate (of speculum metal) ⅜ inch thick by about 3½ inches square, to an extent which seriously impairs the definition; it is sensitive to such distortions to a degree entirely unexpected. This instrument doubles an enormous number of the Fraunhofer lines. Out of 47 lines between C and G marked by Thalen as common to the spectra of two or more bodies, 38 are double or triple, 3 are doubtful (from difficulty of identification), and 6 only are single so far as the instrument can show,

(*d*) Distortion of solar prominences by a diffraction spectroscope. Generally, in such an instrument, the forms seen through the opened slit are either disproportionately extended or compressed along the line of dispersion. If the angle between the normal to the grating and the view-telescope is *less* than that between the normal and the collimator, there will be compression or flattening, and *vice versa*. The mathematical investigation is very simple—

Let n be the order of the spectrum observed.

Let λ be the order of the wave length of the ray.

Let S be the distance between adjacent lines of grating.

Let τ be the angle between normal to grating and telescope.

Let κ be the angle between normal to grating and collimator, and finally $a = \tau + \kappa =$ angle between telescope and collimator, which is supposed constant. Then from the fundamental conditions of spectrum formation $n\lambda = S$ (Sin. τ—Sin. κ) or Sin. $\tau = \frac{n\lambda}{S} +$ Sin. κ, whence $d\tau = \frac{\text{Cos. } \kappa}{\text{Cos. } \tau} d\kappa$, or (Cos. $a +$ Sin. a Tan. τ) $d\kappa$, whence, in general, $d\tau$ will not equal $d\kappa$.

Special cases—

1. If $\kappa = \tau$, there is no distortion—but also no dispersion; it is the case of simple reflection.

2. If $\kappa = 0$, grating being kept normal to the collimator, then $\xi =$ Sec. $a\, d\kappa$.

3. If $\tau = 0$, grating being kept normal to the telescope and moving with it, then $d\tau =$ Cos. $a\, d\kappa$.

4. If $a = 90°$ $d\tau =$ Tan. $\tau\, d\kappa$.

5. If $a = 0$, $d\tau = d\kappa$ and there is no distortion. This is possible only by using the same tube both for collimator and view-telescope, the grating being slightly inclined. The principal difficulty with this form of instrument lies in the reflections from the surface of the object glass, which, it is hoped, may be avoided by a special construction of the lens. An instrument on this plan is in process of construction by the Clarks, for the Physical Laboratory at Princeton, and nearly completed.

ON THE THERMO-ELECTRIC ELECTRO-MOTIVE POWER OF FE. AND PT. IN VACUO.

By Prof. C. A. Young, of Princeton, N. J.

Eisner, a few months ago, published a paper asserting that the thermo-electric power of Antimony and Bismuth is destroyed by removing them from all contact with oxygen, and inserting them in an atmosphere of pure nitrogen. From this he argues that the thermo-electric force in general is due to the contact of the gases which bathe the metals. The following experiment was tried to test the theory.

By the kindness of Mr. Edison and Mr. Upton a vacuum tube was prepared in Mr. Edison's laboratory, containing an iron wire, about 2 inches long, firmly joined to two platinum terminals which passed through the walls of the tube; the tube was exhausted until a 2-inch induction coil spark would not pass ⅛ of an inch in the gauge-tube, indicating a residual atmosphere of about one-millionth. The wire was heated too in candescence during the exhaustion, in order to drive off any possible occluded gases. The platinum wires outside the tube were joined to iron wires, the joinings being covered by glass tubes slipped over them, and a sensitive reflecting galvanometer was included in the circuit. By laying the tube and connected joinings in the sunshine, and alternately shading one or several of the joinings, it was found that the electro motive power of the joinings within the tube was precisely the same as that of those without, and the development of current just as rapid. There was no trace of any modification due to the exhaustion.

ON THE ABSOLUTE INVISIBILITY OF ATOMS AND MOLECULES.

By Prof. A. E. Dolbear.

Maxwell gives the diameter of an atom of hydrogen to be such that two millions of them in a row would measure a millimeter, but under ordinary physical conditions most atoms are combined with other atoms to form molecules, and such combinations are of all degrees of complexity; thus a molecule of water contains three atoms, a molecule of alum about one hundred, while a molecule of albumen, according to Mulder, contains nine hundred atoms, and there is no reason to suppose albumen to be the most complex of all molecular compouuds. When atoms are thus combined it is fair to assume that they are arranged in the three dimensions of space, and that the diameter of the molecule will be approximately as the cube root of the number of atoms it contains, so that a molecule of alum will be equal to

$$(\sqrt[3]{100} = 4.64)\ \frac{4.64}{2000000} = \frac{1}{431000} \text{ mm.}$$

and a molecule containing a thousand atoms will have a diameter of $\frac{10}{2000000} = \frac{1}{200000}$ mm. Now a good microscope, will enable a skilled observer to identify an object so small as the $\frac{1}{4000}$ mm. Beale in his works on the microscope pictures some fungi as minute as that, and Nobert's test bands and the markings upon the *Amphiplura pelucida*, which are of about the same degree of fineness, are easily resolved by good lenses. If thus the efficiency of the microscope could be increased fifty times ($\frac{200000}{400} = 50$) it

would be sufficient to enable one to see a molecule of albumen, or if its power could be increased one hundred and seven times it would enable one to see a molecule of alum.

Now Helmholtz has pointed out the probability that interference will limit the visibility of small objects ; but suppose that there should be no difficulty from that source, there are two other conditions which will absolutely prevent us from ever seeing the molecule.

1st. Their motions. A free gaseous molecule of hydrogen at the temperature of 0°C., and a pressure of 760 mm. mercury, has a free path about $\frac{1}{10000}$ mm. in length, its velocity in this free path being 1860 m. per second or more than a mile, while its direction of movement is changed millions of times per second. Inasmuch as only a glimpse of an object moving no faster than one millimeter per second can be had, for the movements are magnified as well as the object itself, it will be at once seen that a free gaseous molecule can never be seen, not even glimpsed. But suppose such a molecule could be caught and held in the field so it should have no free path. It still has a vibratory motion which constitutes its temperature. The vibratory movement is measured by the number of undulations it sets up in the ether per second, and will average five thousand millions of millions, a motion which would make the space occupied by the molecule visibly transparent, that is it could not be seen. This is true for liquids and solids. Mr. D. N. Hodges finds the path of a molecule of water at its surface to be .0000024 mm., and though it is still much less in a solid it must still be much too great for observation.

2d. They are transparent. The rays of the sun stream through the atmosphere, and the latter is not perceptibly heated by them as it would be if absorption took place in it. The air is heated by conduction, contact with the earth, which has absorbed and transformed the energy of the rays. When selective absorption takes place the number of rays absorbed is small when compared with the whole number presented, so that practically the separate molecules would be too transparent to be seen, though their magnitude and motions were not absolute hindrances.

ON THE AURORA AND ZODIACAL LIGHT OF MAY 2, 1877.

By Henry C. Lewis.

A simultaneous appearance of an aurora and the zodiacal light appeared on this evening, and a comparison between them is here given. The various changes of the aurora are given in detail. A remarkable feature was the formation of a bright streamer which maintained its position relative to the earth for nearly an hour. Meanwhile, the Zodiacal Cone, which was bright early in the evening had moved past the streamer and passed below the horizon. The streamer had remained, like the great pointer, fixed to the earth, and marking its motion, while the heavens revolved past it. This fact was conclusive evidence of the terrestrial character of the aurora and of the cosmical character of the zodiacal light. Another fact leading to the same conclusion was the character of their spectra. That of the zodiacal light was continuous, and that of the aurora was a line-spectrum—the former is such as would be given by sunlight reflected from matter in space ; the latter would be given by an electric discharge through a gas.

OBSERVATIONS ON BRACHIOPODS.

By Prof. Edw. S. Morse.

Mr. Morse gave the anatomical details of some Brachiopods he had studied in Japan, and described the existence of a curious parasitic worm in a large species of Lingula. He also gave further facts regarding the so-called hearts of certain brachiopods, and expressed his belief that they were glands of some kind connected with the reproductive organs.

THE KAMES OR ESKARS OF MAINE.

By Geo. H. Stone, Kent's Hill, Me.

This paper is accompanied by a map showing the courses of the larger Kame-systems of Maine. Omitting short, isolated ridges of gravel, the map shows thirty distinct systems of Kame gravels, varying from five to one hundred and fifty miles in length. The total length of Kames and Kame-plains thus far mapped is about 2000 miles. The map is the result of amateur explorations made at intervals during the past four years.

The paper discusses the following points regarding the Kames :

1. *Kame drift compared with glacial drift.*

The facts show that Kame material has in general been transported farther than the morainal material which was originally derived from the same locality.

2. *The Kame streams.*

The Kames were deposited by currents flowing lengthwise of their courses, and in all but four undecided cases the currents flowed southwards. The Kame streams resembled sub-ærial rivers in their meanderings, their branches, and in all other respects. All the long systems in the State are much higher at their northern than at their southern ends. The water of these rivers is shown to have flowed faster on long down slopes than on up slopes. There is strong reason to believe that most of the water of the melting glacier escaped by superficial channels, unless near the terminal moraine. Except near the coast there are in Maine almost no signs of sub-glacial streams.

3. *The external forms of Kames.*

1. The single ridge. 2. Reticulated plains, composed of a series of reticulated ridges with enclosed funnels or lakelets. 3. The solid or continuous plains, which are broad, flat-topped ridges, showing few or no signs of separate ridges, and often of great height.

4. *The internal structure of Kames.*

Kames are of two kinds—1. The stratified Kame, which is the more common type. 2. The pell-mell Kame.

The same Kame may be stratified in one part of its course and pell-mell in another.

5. *Action of the sea upon the Kames.*

During the Champlain period the sea stood at a height, in the central parts of Maine, about 300 or 350 feet above the present sea level. The Kames are plainly overlain by the marine clays, and the sea greatly modified their form. The difference between the Kame that has been under the sea and that which has not is often very great, and conclusively proves that the Kames proper cannot have been a marine deposit.

6. *Topographical relations of the Kames.*

No general law of relationship between the Kames and the relief forms of the land can be derived from local observations, for there are many purely local relationships. The only invariable rule thus far established is that the Kames never cross hills more than about 200 feet higher than the country lying to the northward. Maine is traversed by numerous ranges of hills trending eastward or northeastward, and the Kame systems never cross the high ranges except by low passes. Low hills they cross freely. The inference of the writer is that the Kames were deposited when the glacier was so far melted that the higher hills rose above the ice surface, and hence the only escape for the waters southward was by the low passes.

7. *Distribution of the Kames.*

A line joining the northern extremities of the Kames is nearly a straight line; it trends nearly northeast and is roughly parallel with the coast. North and west of this line there are occasional short ridges of Kame origin, but no long systems have yet been discovered.

(The publication of papers read before the recent meetings of the American Association for the Advancement of Science will be continued in our next number.—Ed.)